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(71) Applicant
Deutsche Forschungs-und Versuchsanstalt Fur Luft-und
Raumfahrt E.V.,

(Incorporated in FR Germany),

Linder Hohe, 5000 Köln 90, Federal Republic of Germany

(72) Inventors
Joachim Ries,
Heinrich Dorgeloh

(74) Agent and/or Address for Service
Walford & Hardman Brown, Trinity House, Hales Street,
Coventry CV1 1NP

(54) Representation of video images or
scenes transmitted at reduced frame
rate

(57) Video image sequences or scenes
with a relative movement between a
pick-up sensor and the viewed scene,
are transmitted at reduced frame rate.
By interpolation and/or extrapolation
on the basis of two transmitted frames
intermediate frames are generated on
the receiving end of the transmission
line and inserted into the transmitted
frame sequence. Owing to the
movement, certain areas of the
intermediate frame K are derived only
from one reference frame O or the other
reference frame N viz. hatched
extrapolation areas. Other areas are
derived from interpolation between the
two reference frames viz. the
cross-hatched area. Sudden variation of
brightness levels can occur at the area
boundaries. To avoid this, before
reconstruction of the intermediate
frames the mean brightness values for
limited picture areas which represent
the environment of at least one of the
corresponding pels in two successive
transmitted frames are determined.
These brightness values are subtracted
or divided and the brightness value in
the extrapolation zone of the
intermediate frames is corrected in
accordance with the resulting
differences or quotients.

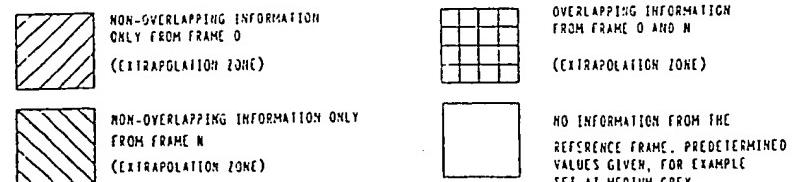
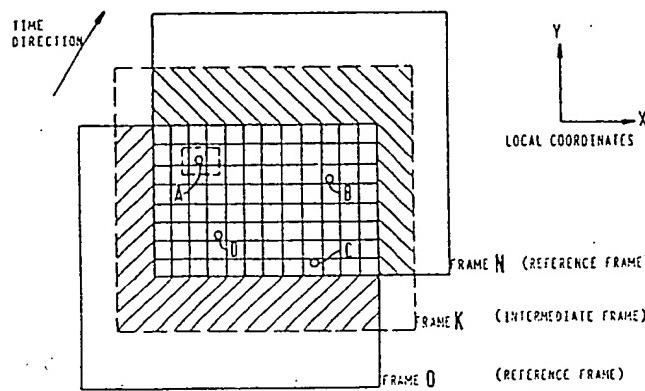


FIG. 2

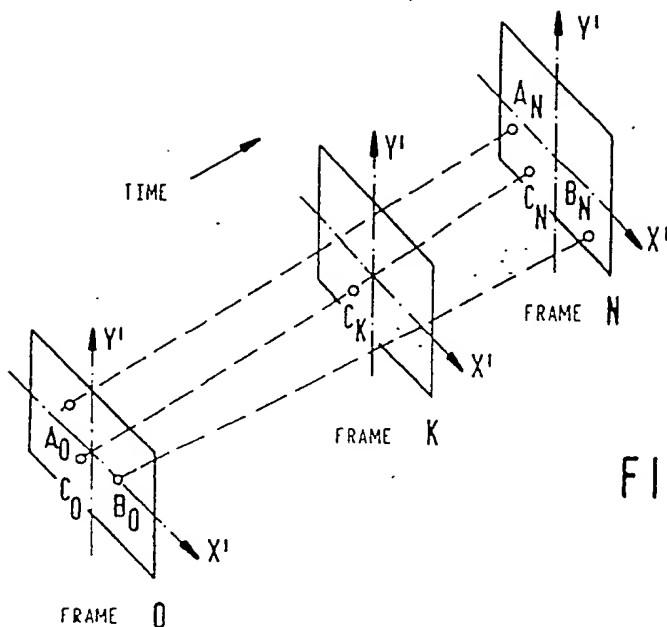


FIG. 1

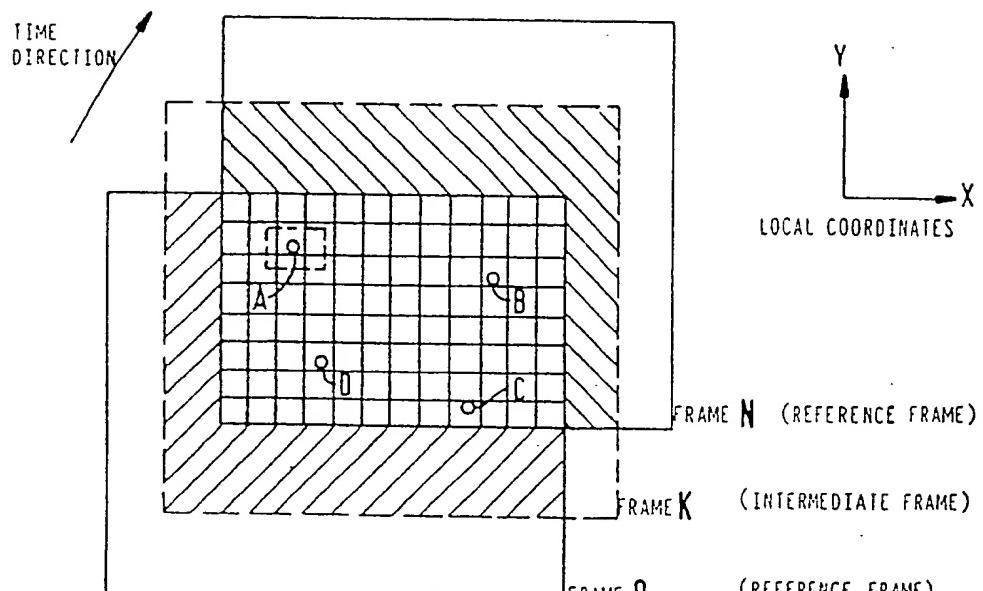
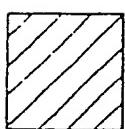
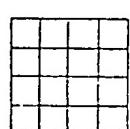
 $0 < K < N$

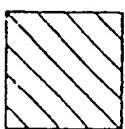
FIG. 2



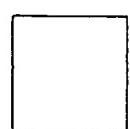
NON-OVERLAPPING INFORMATION
ONLY FROM FRAME 0
(EXTRAPOLATION ZONE)



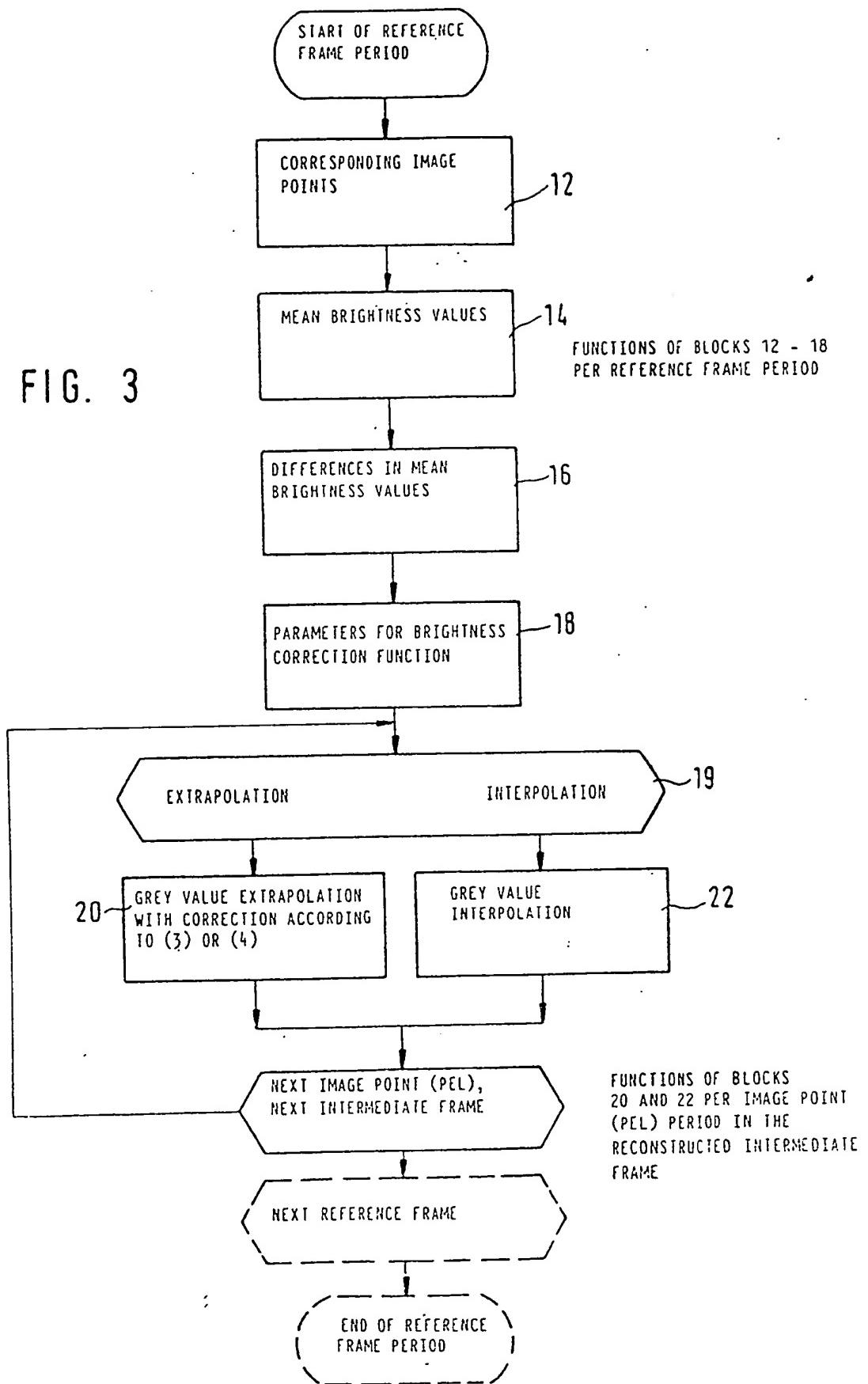
OVERLAPPING INFORMATION
FROM FRAME 0 AND N
(EXTRAPOLATION ZONE)



NON-OVERLAPPING INFORMATION ONLY
FROM FRAME N
(EXTRAPOLATION ZONE)



NO INFORMATION FROM THE
REFERENCE FRAME. PREDETERMINED
VALUES GIVEN, FOR EXAMPLE
SET AT MEDIUM GREY.



SPECIFICATION

Method for the representation of video images or scenes, in particular aerial images transmitted at reduced frame rate

5 The invention relates to a method for the representation of video image sequences or scenes with a relative movement between a pick-up sensor and the viewed scene, such scenes being transmitted at reduced frame rate.

10 The invention refers to a method and an apparatus for the representation of video images, pictures or scenes, in particular aerial pictures with a relative movement between a pick-up sensor and the scene transmitted at reduced frame rate, in which by interpolation and/or extrapolation on the basis of two transmitted frames intermediate frames are generated and inserted into the transmitted frame sequence and in which the position of pels being identical in the two transmitted frames are determined from the relationship of the positions of at least two pels on different vertical and horizontal coordinates in each of the two

15 transmitted frames as described in U.S. patent specification 4,496,972, to which reference is made.

The intermediate frames are constructed of two reference frames recorded at different times (e.g. 1 second apart) whose frame information partly overlaps.

In general with a frame movement in the x and y direction an intermediate frame K inserted in the sequence possesses three zones containing information of at least one of two reference frames. In the overlap zone of the two reference frames O and N information from both frame O and N is available. Two further zones include information only present in one of the two reference frames O or N. In further zones there is no reference frame information.

The intermediate frames are composed according to these conditions. Interpolation between the grey values or frames O and N is possible in the overlap zone. By weighting the grey values depending on the time distance of the intermediate frame to be reconstructed from the reference frames a gradual changeover of the grey values from frame O to frame N can be reached. The zones for which information is available only from one of the two reference frames are taken directly from the relevant frame, i.e. without weighting depending on the time distance (extrapolation), compare German specification DE-OS 34 08 061. As an alternative to the interpolation the extrapolation can be extended to the overlap zone. Zones with no reference frame information are given a predetermined grey value, e.g. medium grey value.

If the lighting conditions between the recordings of two successive reference or transmitted frames change then the average brightness (i.e. the mean value of the grey value distribution) can differ in the extrapolation zone of the intermediate frames and in the interpolation zone or in parts of these zones. This difference affects the reproduction quality of the intermediate frames and has a negative visual effect particularly at junctions between these zones, occurring as an abrupt change in the grey level.

The object of the invention is to reduce the abrupt brightness changes at the junctions between interpolation zones and extrapolation zones where information from just one reference frame is available.

The invention solves this task by a method and an apparatus for the representation of video images, pictures or scenes, in particular aerial pictures with a relative movement between a pick-up sensor and the scene
40 transmitted at reduced frame rate, in which by interpolation and/or extrapolation on the basis of two transmitted frames intermediate frames are generated and inserted into the transmitted frame sequence and in which the position of pels being identical in the two transmitted frames are determined from the relationship of the positions of at least two pels on different vertical and horizontal coordinates in each of the two transmitted frames, wherein before reconstruction of the intermediate frames for limited picture areas which
45 represent the environment of the position of at least one of the corresponding picture elements (pels) in two transmitted frames the mean brightness values of these picture areas are determined, these brightness values are subtracted or divided and the brightness value in the extrapolation zone of the intermediate frames is corrected according to the resulting differences or quotients.

Further features of the invention are described with reference to the drawings.
50 The process involved expands the existing intermediate frame interpolation process so that the average brightness of the extrapolation and interpolation zones over the frame can be matched to reduce the brightness changes stated above and therefore avoids the negative visual effects. 50

The present invention will be more readily appreciated by reference to the following detailed description when read in light of the accompanying drawing in which:

55 Figure 1 shows the reconstruction principle of intermediate frames. 55
 Figure 2 shows an intermediate frame reconstructed from two referenced frames.
 Figure 3 is a block circuit diagram of intermediate frame reconstruction with adjusted brightness.
 Figure 1 shows the time relationship of two transmitted frames (O and N) and an intermediate frame (K)
 reconstructed on the receiving end of a transmission line and having the picture element (pel) positions A_0, A_N
 60 and B_0, B_N respectively determined by measurement as well as the allocated picture elements C_K, C_O and C_N ,
 respectively determined by calculation based on a linear model. 60

The relationship between the pel position of an object and time, i.e. its displacement between different frames, is determined by the laws of optical projection and geometry. It can be approximated by a linear characteristic, as shown in Figure 1. If the positions of corresponding pels in the two reference frames are known, for example positions A_0, B_0 in frame O and A_N, B_N in frame N, the remaining pels of the picture field,

e.g. for the pels C_O, C_N can be determined from the relationship of the distance between the pels in accordance with the Ray Ratio Law. The relationship of the distance between the pel C_O and C_N with the coordinates x'_{CO}, y'_{CO} and x'_{CN}, y'_{CN} and the relevant pel C_K with the coordinates x'_{CK}, y'_{CK} in a frame K is characterized by a specific straight line between frame O and N and can be determined from the coordinate relationship, in a known manner as described in U.S. patent specification 4,496,972.

Figure 2 shows the reference frames O and N which are displaced in time and according to their coordinates x and y. In addition the intermediate frame K to be reconstructed is shown by the broken lines. As illustrated, the overlapping zones indicated by square hatching contains information from both frames O and N. No overlap occurs in the areas with oblique hatchings. Information for these zones is available from one of the successive frames O and N, i.e. the zone with hatching slanting to the right is from frame N and the zone with the hatching slanting to the left is from frame O. Whilst the pels in the overlapping zone can be reconstructed by interpolation those in the non-overlapping zone are extrapolated using the information from one of the reference frames. For zones for which no information is available predetermined grey values are given, for example a medium grey.

The above shows that with major changes in the mean brightness values between successive reference frames a smooth changeover from the brightness of one frame to the next is only guaranteed in the overlapping zone where interpolation is possible. In the extrapolation zone only information from one of the reference frames is available. This leads to sudden changes in the grey value and therefore in the brightness at the junction between the interpolation zone and the adjacent extrapolation zones. Such abrupt grey changes have a negative visual effect.

Such abrupt changes are largely avoided by the process to be described below. This process uses the average brightness resulting from brightness averagings of limited picture areas which correspond in both reference frames. Displacement measurement techniques which can supply the positions of the matching pels in the frames or displacement values for those pels required for the interpolation of the intermediate frame and which operate according to the area correlation processes provide means brightness values of corresponding picture zones in both reference frames.

The differences in the average brightness of corresponding picture areas are used to determine the parameters of a function which is used to correct the brightness in the corresponding picture areas in the intermediate frame for any pel in the intermediate frame in the case of extrapolation. The parameters are determined by solving a system of linear equations containing the brightness differences as well as their coordinates in one of the reference frames.

The process represents an improvement over the weighted interpolation of pels in intermediate frames in that exposure differences in successive reference frames no longer result in noticeable abrupt brightness changes at the junctions between interpolation and extrapolation zones.

Details of the process are described in the following.
From two successive reference frames O and N a number "n" of corresponding limited areas is selected. The actual number depends on the content of the reference frames. Corresponding limited picture areas are referred to hereinafter as picture area pairs. The size of picture areas is variable and can be e.g. 20x20 pels. Corresponding pairs of pels which are required to reconstruct the intermediate frames known from the displacement measurement techniques can be used as the centre of said picture area pairs.

Such a picture area is shown in Figure 2 by the broken line around pel A. In the reference frame O the pel in the centre of this picture area has the coordinates $A_O = (x_{oA}, y_{oA})$ and in reference frame N said pel has the coordinates $A_N = (x_{NA}, y_{NA})$. This figure shows further pels B, C and D to which corresponding pairs of picture areas in two successive frames are allocated.

The determination of the correspondence between reference frame O and N resulting therefrom and the determination of the centre pels of the picture areas is carried out in block 12 of the circuit diagram shown in Figure 3. For each of the picture areas in the two successive frames O and N respectively a mean value of the brightness u_{oi} and u_{Ni} (Figure 3, block 14) is to be determined and thereafter the difference between these mean values (Figure 3, block 16) in accordance with the formula:

$$\mu_{Di} = \mu_{Ni} - \mu_{oi} \quad (1)$$

The differences together with the corresponding frame coordinates of pels $A_o, B_o, C_o, D_o, \dots$ or $A_N, B_N, C_N, D_N, \dots$ are used in a system of preferably linear equations where the solution produces the parameters $a_1 \dots a_n$ for the brightness correction function (2) (block 18).

In this, "n" represents the number of corresponding picture areas.

For example (if n = 4):

$$\mu_o(x_o, y_o) = a_1 x_o y_o + a_2 x_o + a_3 y_o + a_4 \quad (2)$$

Alternatively the coordinates in reference frame O (x_o, y_o) or in N (x_N, y_N) corresponding to the mean values can be used as reference variables in the formula, for example in (2).

The grey value of a pel in an intermediate frame to be determined in the extrapolation zone can be calculated according to the extended interpolation formulae (3 and 4), block 20.

$$I_K^{(o)} = I_o(x_o, y_o) + g^{(o)}(K, N) \mu_D(x_o, y_o) \quad (3)$$

$$I_K^{(N)} = I_N(x_N, y_N) + g^{(N)}(K, N) \mu_D(x_o, y_o) \quad (4)$$

5 with for example

$$g^{(o)}(K, N) = \frac{K}{N} \quad (5)$$

$$g^{(N)}(K, N) = \frac{K - N}{N} \quad (6)$$

10 The time-weighting factors $g^{(o)}$ and $g^{(N)}$ determine the time related continuous changeover in the brightness correction between reference frames O and N. The formulae (5 and 6) indicate the special case of time-linear changeover.

15 The above describes the process on the basis of subtraction of the mean brightness values. A division of the mean brightness values can also be used according to the following formulae:

$$v_i = \mu_{Ni} / \mu_{oi} \quad (7)$$

$$v_i(x_o, y_o) = a_1 x_o y_o + a_2 x_o + a_3 y_o + a_4 \quad (8)$$

20 $I_K^{(o)} = g^{(o)} v(x_o, y_o) I_o(x_o, y_o) \quad (9)$

$$I_K^{(N)} = g^{(N)} v(x_o, y_o) \frac{1}{I_N(x_N, y_N)} \quad (10)$$

25 *Symbols*

u_{oi}	Mean brightness value in reference frame O relating to matching pel i.	
u_{Ni}	Mean brightness value in reference frame N relating to matching pel i.	30
u_{Di}	Difference between corresponding mean values relating to matching pel i.	
v_{Di}	Quotient of corresponding mean values.	35
$u_D(x_o, y_o)$	Function of brightness differences.	35
$v_D(x_o, y_o)$	Function of brightness quotients.	
$a_1, a_2, a_3, \dots, a_n$	Coefficients.	40
x_o, y_o	Pel coordinates for frame O.	
x_N, y_N	pell coordinates for frame N.	45
N	Number of frames between two reference frames.	45
K	Position ($0 < K < N$) of an intermediate frame.	
$I_K^{(o)}$	Grey value of a pel in the intermediate frame in the position K when only a pel reference to the frame O exists (extrapolation zone).	50
$I_K^{(N)}$	Grey value of a pel in the intermediate frame in the position K where only a pel reference exists to the reference frame N (extrapolation zone).	
$g^{(o)}(K, N)$	Time-weighting factor according to the intermediate frame position K in respect to the reference frame O.	55
$g^{(N)}(K, N)$	Time-weighting factor according to the intermediate frame position K in respect to reference frame N.	60

1. A method and an apparatus for the representation of video images, pictures and scenes, in particular aerial pictures with a relative movement between a pick-up sensor and the scene transmitted at reduced frame rate, in which by interpolation and/or extrapolation on the basis of two transmitted frames intermediate frames are generated and inserted into the transmitted frame sequence and in which the position of pels being identical in the two transmitted frames are determined from the relationship of the positions of at least two pels on different vertical and horizontal coordinates in each of the two transmitted frames, wherein before reconstruction of the intermediate frames for limited picture areas which represent the environment of the position of at least one of the corresponding picture elements (pel) in two transmitted frames the mean brightness values of these picture areas are determined, these brightness values are subtracted or divided and the brightness value in the extrapolation zone of the intermediate frames is corrected according to the resulting differences or quotients. 5
2. Method according to Claim 1, wherein the mean brightnesses of limited picture areas around the positions of at least four corresponding pels are used as the basis for extrapolation. 10
3. Method according to Claim 1 or 2, wherein for the limited picture areas those pels are chosen which are selected to form the basis for reconstructing the intermediate frames. 15
4. Method according to Claim 1, wherein from at least two differences or quotients a function of the dependencies of the limited picture area is derived. 15
5. Method according to Claim 4, wherein differences or quotients in the brightness values for further pel positions are calculated from said function with the coordinates of these further pel positions as variables. 20
6. Method according to Claim 4, wherein the function is a polynom of the first order of the coordinates of one of the images transmitted.
7. A method for the representation of video images in accordance with Claim 1 and substantially as described herein with reference to the accompanying drawings. 20

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